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The utilization of pollen by a natural population of *Entomobrya socia*

BY

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INTRODUCTION

A primary food item for epigeic Collembola is pollen (GISIN, 1948). By direct observation I have quantified aspects of the utilization of a pollen-rich diet by *Entomobrya socia.* From above the observer is unable to distinguish feeding from intervals when the animals remain motionless over food. As a result the field observations present data on egestion rates.

In Baton Rouge, Louisiana *E. socia* inhabits residential lawns formed of St. Augustine grass *(Stenotaphum secundatuni).* This perennial grass produces a mat of coarse blades and rapid growing runners. With a dissection microscope springtails were observed on grass surfaces in April, 1978. Their diet included pine pollen (*Pinus glabra* Walt.) that appeared as sparse white powder on grass surfaces.

I. — METHODS

Data from large individuals were collected between 1600 and 1800 hours using a second counter. The counter allowed time intervals and total elapsed time to be measured synchronously. After the first defecation, two intervals were timed for each individual.

Population samples of *E. socia* were collected on 8 April 1978 with a modified household vacuum cleaner. Each sample included the animals removed from an area 17.3 cm × 28.4 cm within a frame. Individuals from four samples were sorted and mounted on slides with others of the same head length.

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After clearing, the outlines of the midgut contents and hindgut contents (fecal pellets) were drawn and their dimensions measured. Using 20 × magnification, each unit in the eyepiece scale was equivalent to .025 mm. The volumes of the contents were considered to approximate combinations of spheres, cylinders and cones. By adding the shapes most similar to the contents of each individual, an estimate of food and fecal pellet volume was obtained.

II. — RESULTS

The presence of the exines of many pollen grains in the feces suggests that the outer coat is not digested. The average interval between defecations ranged from 2.7 minutes to 8.3 minutes. Excluding the data from 13 April (because it followed 24 hours after a rainfall), the overall average was 4.5 minutes (Tab. I). There are insufficient data to describe a significant relationship between temperature and egestion rate. On days with higher temperatures, for example 8 April with a temperature of 25.6° C, *Entomobrya* was too active to permit observation. As animals seemed to be feeding most of the time, these rates are probably maximal ones for these temperatures.

TAB. I

Rates of egestion in *Entomobrya socia*

Date	$\bar{x}$ interval (in sec) between defecations	SD	Number animals	1800 Air température (°C)
31 Mar. . . .	258		1	23.9
1 Apr. . . .	265	79.3	2	23.9
2 Apr. . . .	258	60.3	3	23.9
6 Apr. . . .	310	153.6	4	23.3
7 Apr. . . .	249	105.1	4	24.4
13 Apr. . . .	327		1	22.8

As is expected, the estimates of the volume of midgut contents (Tab. II) are a function of body size. Similarly fecal pellet size is depend on body size, but pellet size increases with growth at a slower rate than gut size. The smallest size category of *Entomobrya* midgut contained food equivalent to the volume of 6 fecal pellets, and the largest individual contained food equivalent to 32 of its pellets.

Animals of .27 mm or greater head lengths, termed large, constituted 47 % of the population as estimated from the samples (Tab. III). Of the large animals, 70 % had guts that were more than half full and only 6 % had empty guts.

TAB. II

Estimates of midgut content volumes and fecal pellet volumes in individuals of various body sizes Measurements and standard deviation (SD) are given in $mm^3 \times 10^{-3}$

Head Length (in mm)	$\bar{x}$ volume gut contents (SD)	n	$\bar{x}$ volume fecal pellets (SD)	n	gut volume / pellet volume
< .125.....	.15 (.08)	3	.025	1	6.0
.15-.25.....	.75 (.71)	16	.088 (.05)	7	8.5
.27-.37.....	3.07 (1.37)	12	.194 (.06)	7	15.8
.40-.6.....	14.09 (14.57)	4	.884 (.14)	2	15.9

TAB. III

Gut condition of animals (from four pooled samples) collected 8 April 1978

Head Length (in mm)	number of individuals	number with gut > half full	number with gut empty
< .125.....	1	1	
.15-.25.....	57	45	5
.27-.37.....	42	32	0
.40-.6.....	9	4	3

III. — DISCUSSION

From the data collected the transit time of food through the gut can be estimated. In large animals with a midgut volume equal to 16 pellet volumes and with defecation every 4.5 minutes, about 1.2 hours is the minimum transit time.

For comparison, only 2.5 hours elapses from pollen ingestion by honeybees until it is defecated (STANLEY & LINSKENS, 1975), eventhough the honeybee digestive tract is several times the length of that in the springtail. *Sinella coeca* requires 8-12 hours (at 20-22° C) from ingestion to egestion of starch (HUMBERT, 1974). The oribatids *Protoribates lophotrichus* and *Platynothrus peltifer* when fed on decaying leaf material and fungus (at unspecified temperatures) have 8-9 hour transit times (HARTENSTEIN, 1962 a, 1962 b).

Considering large *E. sccia* for which egestion rate has been measured, the quantity of food processed can be estimated. (This is calculated by multiplying pellet volume by pellets per hour by number of animals with gut more

than half full per meter^2 and adding this product for the two sizes.) When feeding continuously these will process .65 mm^3 per hour per m^2.

In *Orchesella villosa* the dry weight of the gut contents (primarily algae and undigested fungal hyphae) measured 20 % of dry body weight (KILBERTUS & VANNIER, 1979). If this ratio holds for *E. socia*, it can potentially process food equal to its body weight approximately every 6 hours.

Rates of ingestion and egestion probably vary with time of day and time relative to the molting cycle. The absence of *E. socia* from grass surfaces before about 1600 hours and its increasing abundance thereafter suggests that

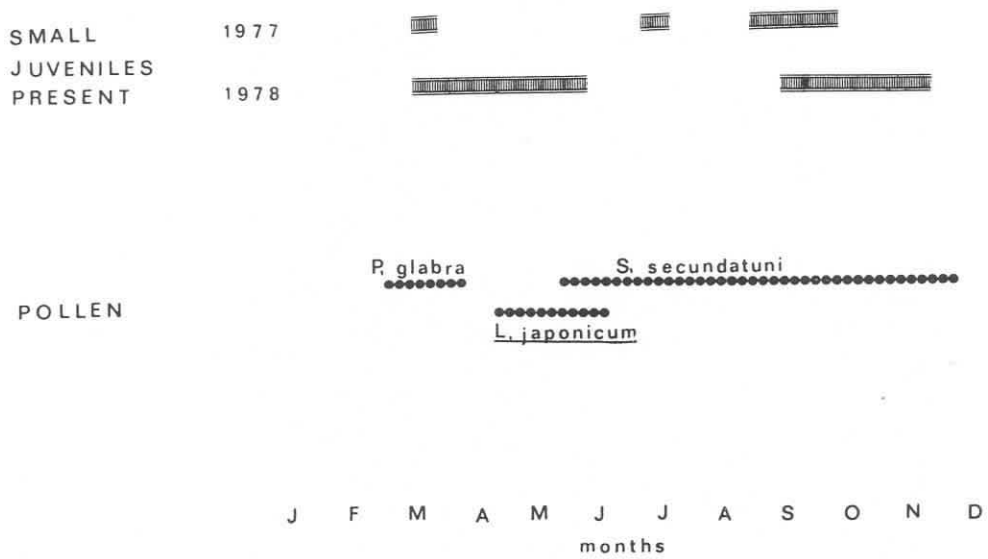

FIG. 1. — Seasons of pollen and small juvenile abundance. Note that the flowering of *S. secundatuni* during this period is dependent on the mowing schedule.

it exhibits a diurnal rhythm of vertical movements, as has been shown in other species (e.g. LEUTHOLD, 1961). This probably influences its access to pollen. In *Sminthurides malmgreni* Tullberg the activity rhythm is correlated with a diurnal rhythm of feeding (KRISTENSEN & VESTERGAARD, 1975). Thus the rates estimated for *E. socia* possibly characterize only part of each day.

Ideally ingestion and egestion rates should be measured near the midpoint of feeding intervals within each intermolt. Because the timing of ecdyses can be influenced by rainfall (JOOSSE, 1975; WALDORF, unpublished), the rates probably differ as a function of proximity to most recent rainfall. All observation dates (except 13 April) followed rainfall by more than 7 days. As the population samples show, most animals at this time have nearly full guts.

Unlike *Onychiurus* (SCOTT & STOJANOVICH, 1963), *Entomobrya* utilizes pollen without digesting the exine. This is consistent with the absence of cellobiase from epigeic species (ZINKLER, 1968). This enzyme with others would be required to digest the cellulose in the exine.

Of the contents of pine pollen, 12-17 % is protein (TODD & BRETHERICK, 1942). Pollens incubated in sucrose solution will minutes later release amino acids and proteins (LINSKENS & SCHRAUWEN, 1969). Specifically at 25° C in 10 % sucrose solution 50 % of the free amino acids in pollen are released during the first minute. If release occurs as rapidly in *Entomobrya,* this explains in part the brief gut transit time.

In *Heliconius* butterflies pollen feeders produced more eggs and had longer reproductive periods than other species (GILBERT, 1972). Amino acids from pollen were traced into developing eggs. Figure 1 presents the seasons of pollen and juvenile *Entomobrya* abundance. The major local sources of pollen are depicted: pine *(P. glabra)*, the surrounding hedge, *(Ligustrum japonicum*), and lawn grass *(S. secundatuni)*. The flowering dates of the grass within the period shown are dependent on the mowing schedule. In the absence of data on periods of oviposition, the smallest of the juveniles are represented. In both years immature *Entomobrya* appeared about two weeks after pine pollen release. It is possible that the nutrients in pine pollen influence the onset of reproduction. For the remainder of the year the relationship is not clear.

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SUMMARY

Individuals in a natural population of *Entomobrya socia* were observed as they fed on *Pinus* pollen in a lawn (*Stenotaphum secundatuni*). Egestion rates were recorded and estimates made of gut and fecal pellet volumes and population density . At 24° C with defecation every 4.5 minutes about 1.2 hours is required to replace gut contents. Seventeen percent of the contents is lost with each defecation in small animals; only 6 % is lost in large animals. When feeding continuously large individuals can process .65 mm^3 per hour per m^2. As a protein-rich food, the availability of pollen might influence the onset and duration of reproduction in females.

RÉSUMÉ

Les individus d'une population naturelle d'*Entomobrya socia* en train de se nourrir de pollen de *Pinus* ont été observés sur une pelouse (*Stenotaphum secundatuni*). La durée du transit à travers le tube digestif a été enregistrée et des estimations du volume de l'intestin et des boulettes fécales d'une part et des densités de population d'autre part ont été effectuées. A 24° C, avec une défécation toutes les 4, 5 minutes, le remplacement total du contenu intestinal dure environ 1, 2 heures. 17 % du contenu intestinal est évacué à chaque défécation chez les petits individus alors que cette proportion n'est que de 6 % chez les grands individus. En se nourrissant en continu, les grands individus peuvent

ingérer 0,65 $mm^3/h/m^2$. Le pollen étant une nourriture très riche en protéines, sa disponibilité peut influencer le déclenchement et la durée de la période de reproduction chez les femelles.

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